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ENCHANT - General characterisation of near term quantum advantage regimes

Quantum computing is a very rapidly developing field with the potential to address problems that were considered intractable some decades ago. Despite the daunting technological challenge, quantum devices have reached a size for which their calculations cannot be fully simulated by classical computers. Nevertheless, noise and short coherence times hinder their actual performances, and the algorithms with proven quantum advantage will not be implemented soon. This intermediate scenario opens exciting avenues and poses several challenges. How to systematically identify tasks where a quantum advantage over classical computers can be obtained in the near term? Once they are found, how to certify that the same computation cannot be reproduced by any classical means? ENCHANT, gENeral CHAracterisation of Near-Term quantum advantage regimes, proposes a radically new vision: the development of a comprehensive toolset to characterise the remarkable realm of near-term quantum advantage regimes. The toolset is meant to provide three fundamental assets for such an ambitious task: (A) a general framework encompassing the algorithms that can be run in current devices, compatible with their main limitations and constraints. We envision to obtain that by means of a careful classification of the families of states that can be obtained as the output of near-term quantum computation, (B) an assortment of task-tailored classical algorithms to simulate the performances of quantum devices. Here the interest is two-fold: to provide comparative methods to assess the quality of those devices and to identify tasks with no quantum advantage over classical computers, (C) a selection of techniques to certify quantum effects in computation and relating them to the hardness of simulating the same task classically. To make them amenable for quantum advantage regimes, we look for methods that rely on partial information about a quantum system.

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Total EU Contribution: Euro 188.590,08
Call ID: HORIZON-MSCA-2023-PF-01
Project Duration in months: 24
Find out more: https://cordis.europa.eu/projects/en